



# Armed Forces College of Medicine (AFCM)

## Histology Department



# Erythropoiesis & Bone Marrow Structure

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# Intended Learning Objectives (ILOs)



**By the end of this lecture the student should be able**

**to:**

- **Describe the microscopic structure of the bone marrow.**
- **Describe the cellular changes along the series of erythropoiesis.**
- **Interpret the changes in the reticulocyte count in the blood.**

# Lecture Plan



- 1. Part 1 (3 min): Introduction to hematopoiesis**
- 2. Part 2 (40 min): Steps of erythropoiesis and bone marrow structure.**
- 3. Part 3 (3 min): Summary**
- 4. Lecture Quiz: (4 min)**



# Hematopoiesis

(Hemato= blood / Poiesis= making).

- **Definition:** The process by which blood elements are produced.
- **Site:**

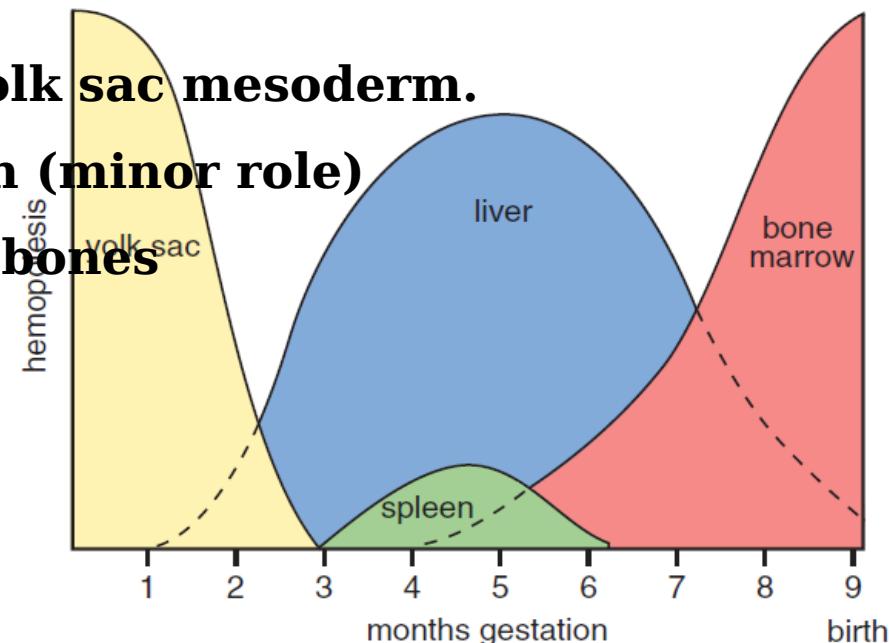
## o Prenatal hematopoiesis

- In the 1<sup>st</sup> trimester (starting from W3): in the yolk sac mesoderm.
- In the 2<sup>nd</sup> trimester: in liver (mainly) and spleen (minor role)
- In the 3<sup>rd</sup> trimester: in bone marrow of specific bones

## o Postnatal hematopoiesis:

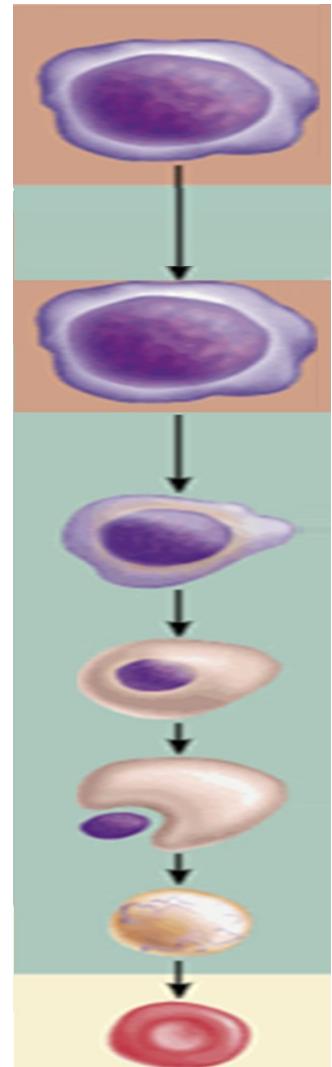
- occurs in the red BM and lymphatic tissues

As the circulating blood cells have a relatively short life span and must be continuously replaced





# Hematopoiesis



**Stem cells  
( BM)**

**Progenitor  
cells  
(CFU)**

**Precursor  
cells  
(=Blasts)**

**Mature cell  
(=Functioning  
cell)**

**Self renewal**

**Multipotent (give all the blood cell types)**

**Capable of ~~asymmetric~~ division**

**Less self renewal**

**Less potential**

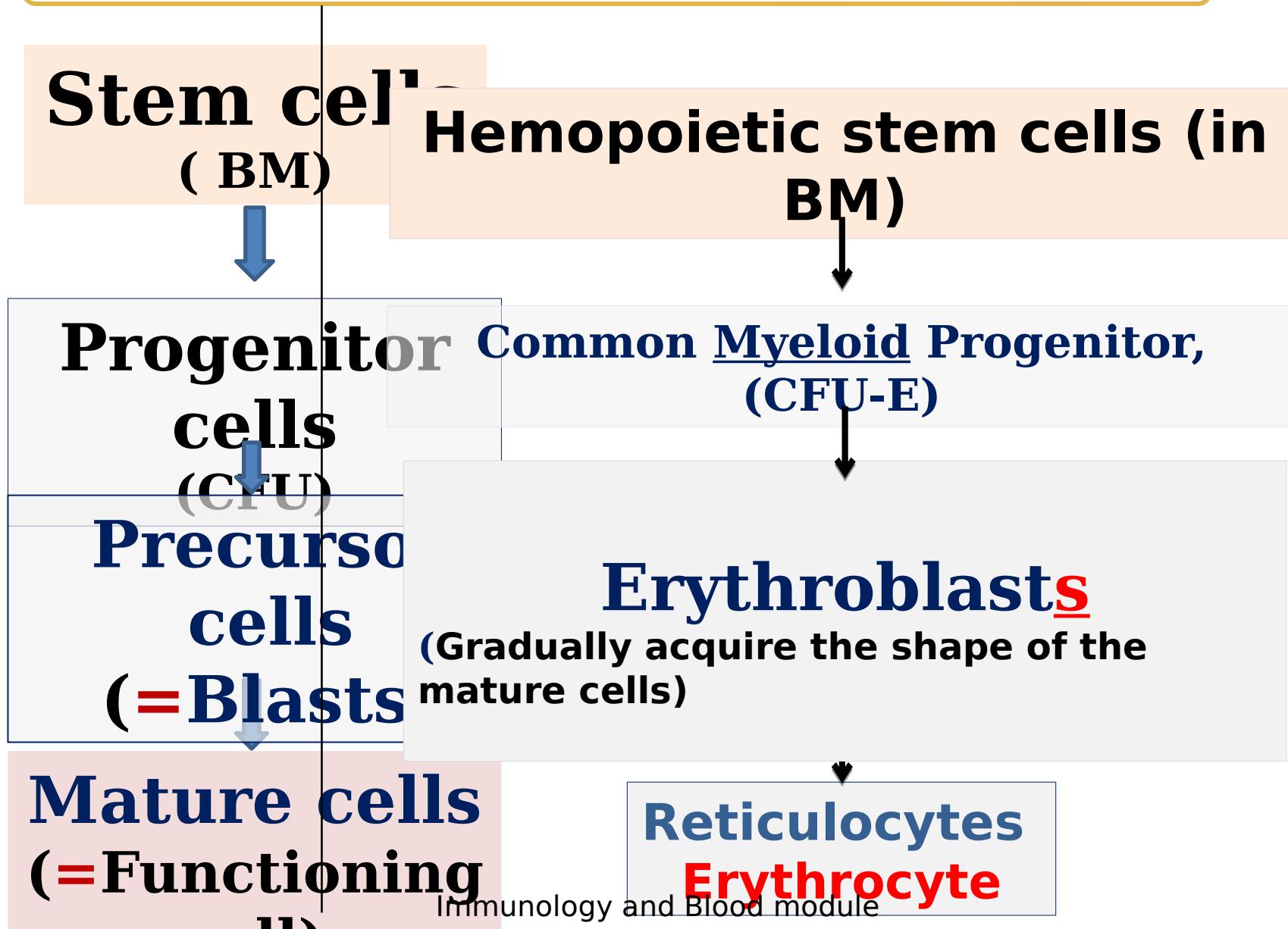
**Committed to produce specific blood cells (= Form colonies of only one cell type)**

**Gradually acquire the characteristic shape of the mature cells**

# Erythropoiesis



# Erythropoiesis



Erythrocyte



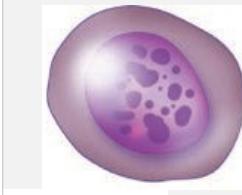
# Erythropoiesis



Common Myeloid Progenitor,  
(CFU-E)

**Notice changes in:**

- **Size**
- **Nucleus**
- **Cytoplasm**



**Pro-erythroblast**

(free ribosomes)



Basophilic Cytoplasm



**Basophilic Erythroblast** →

(free ribosomes)

Basophilic Cytoplasm



**Polychromatophytic erythroblast** →

(free ribosomes and Hb) (last mitosis)

Basophilic & Acidophilic C.



L  
→  
d v



**Normoblast**

dark nuclei. Then, it will eject the nucleus)

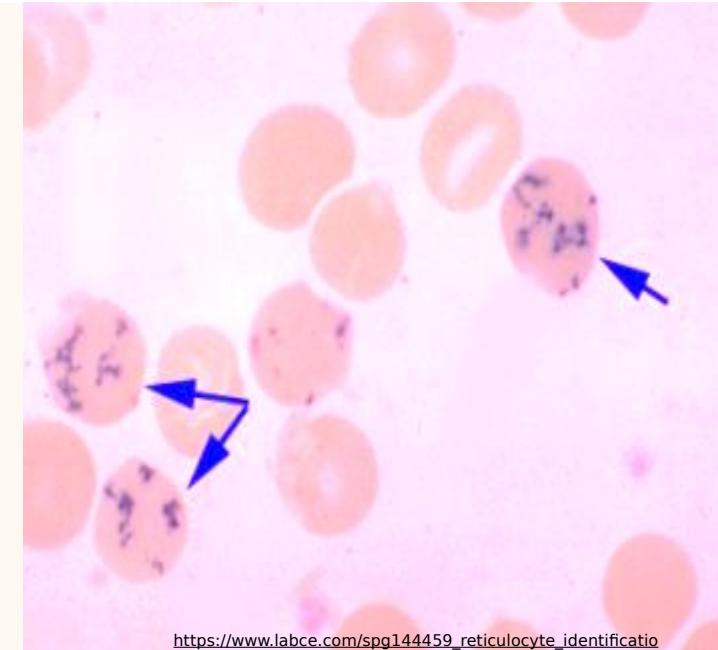
**Erythrocyte**





# Reticulocytes (Polychromatophytic erythrocytes)

- Immature cells, slightly larger than erythrocytes
- **Number:** **1-1.5%** of erythrocytes in the peripheral blood.
- **LM:** (**brilliant cresyl blue**) Show faintly stained basophilic network,
- **Fate:** soon loses its polyribosomes and becomes mature erythrocytes
- **Clinical significance:** Increases from **blood loss** (ex: chronic ribosomal RNA)anemia).



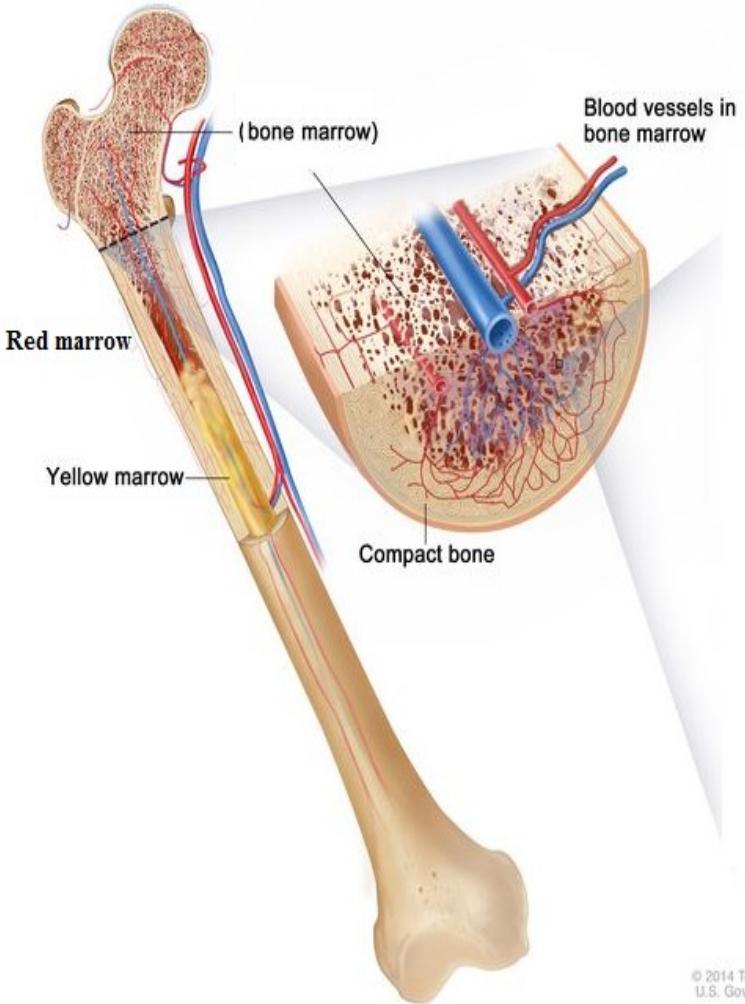
## The corrected reticulocyte count:

- It evaluates the degree of patient's BM response to the anemic stimulus.
- It is calculated as:

**(Patient's hematocrit) × (reticulocyte count) /“normal” hematocrit (=45%)**

- The corrected reticulocyte count: <2% indicates **poor** BM response

>3% indicates **good** BM



# Bone Marrow

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# Bone Marrow

## Structure:

**1- Stroma:** formed of

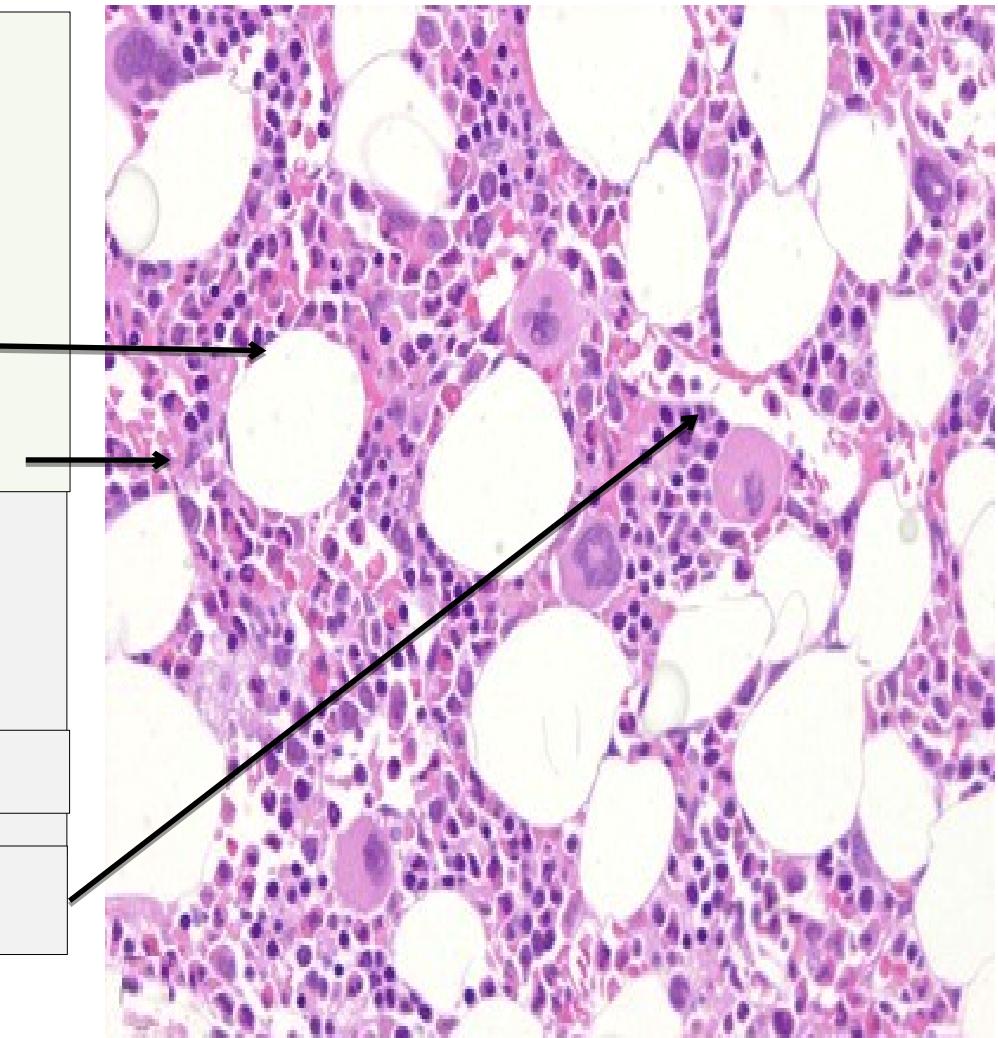
- Reticular fibers, **collagen** fibers: for support.
- **Stromal cells (=Reticular cells):** special fibroblasts
- **Fat storing cells**

**(Hemopoietic cords)**

- **Population of free developing cells**  
(erythroid, myeloid and megakaryocytic lineages)

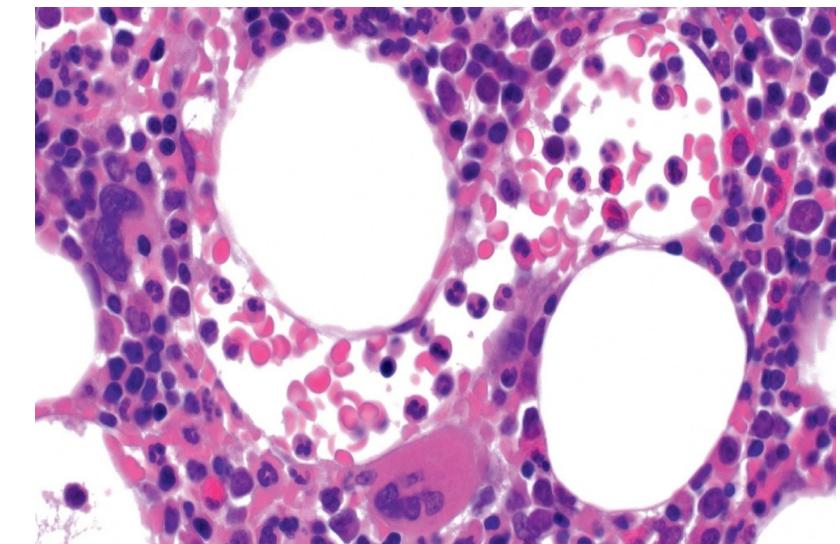
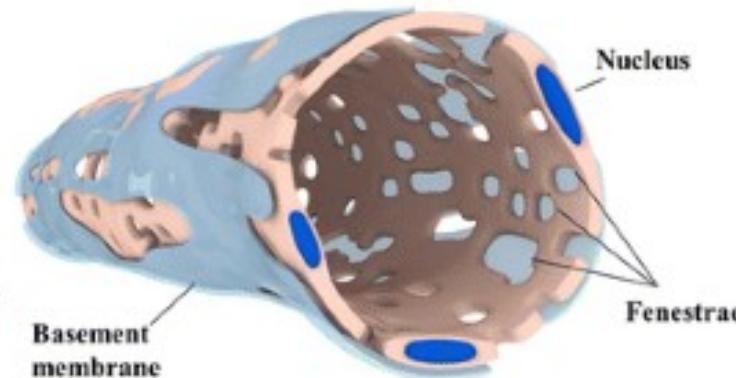
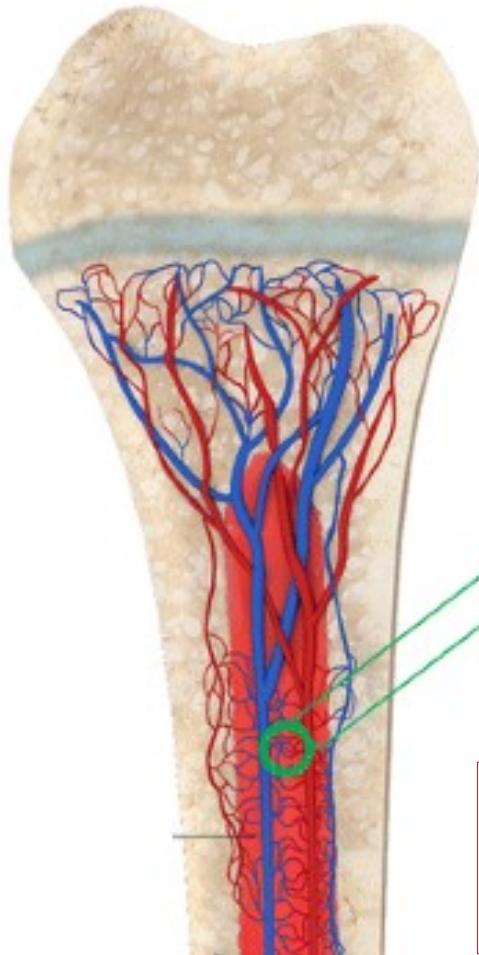
**3-Macrophages:** phagocytosis of old RBCs.  
They are **free** mobile cells (**not fixed**).

**4-Blood sinusoid:**



## **BM Blood sinusoid:**

- Thin wide irregular capillaries, formed of
  - 1- Fenestrated endothelial cells
  - 2- Discontinuous basement membrane



**Why  
Fenestrated ???**  
**Through which newly differentiated blood  
cells and platelets enter the circulation**

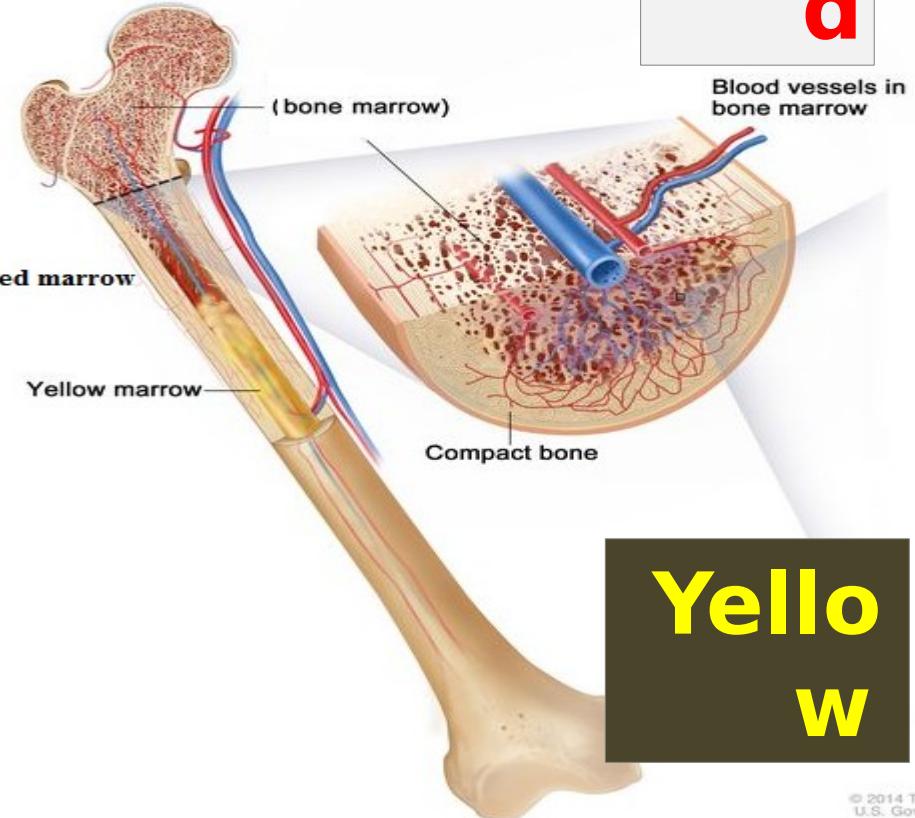
# Bone Marrow

**2  
Types**

**2  
Ratios**

**BM Biopsy: most commonly from “iliac crest”**

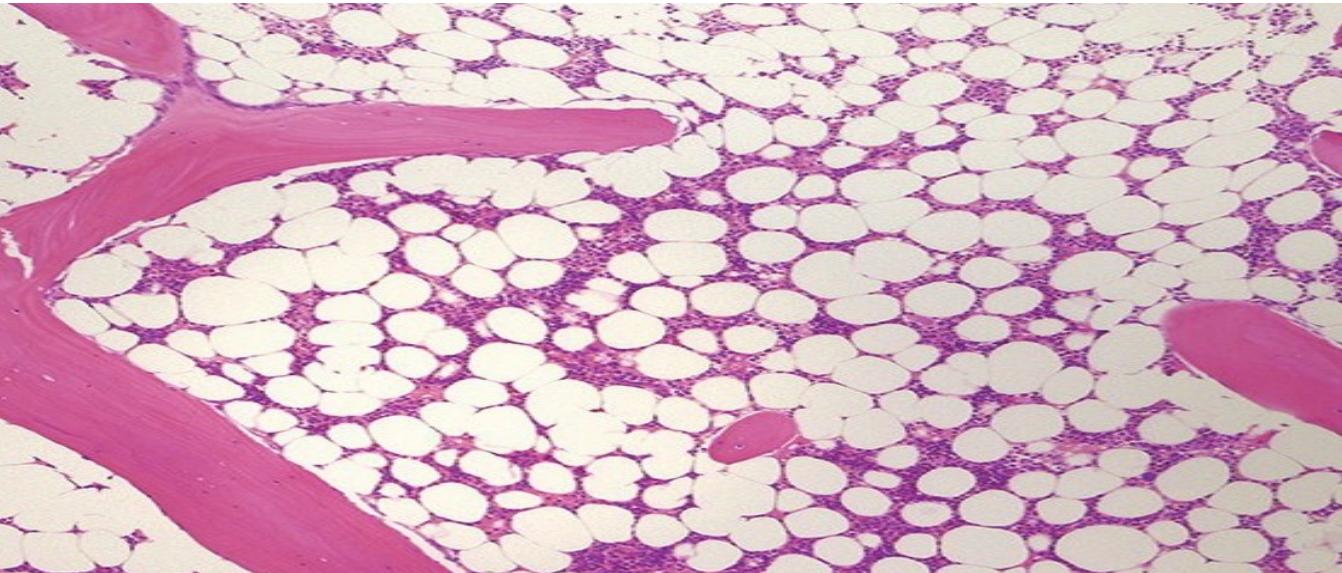
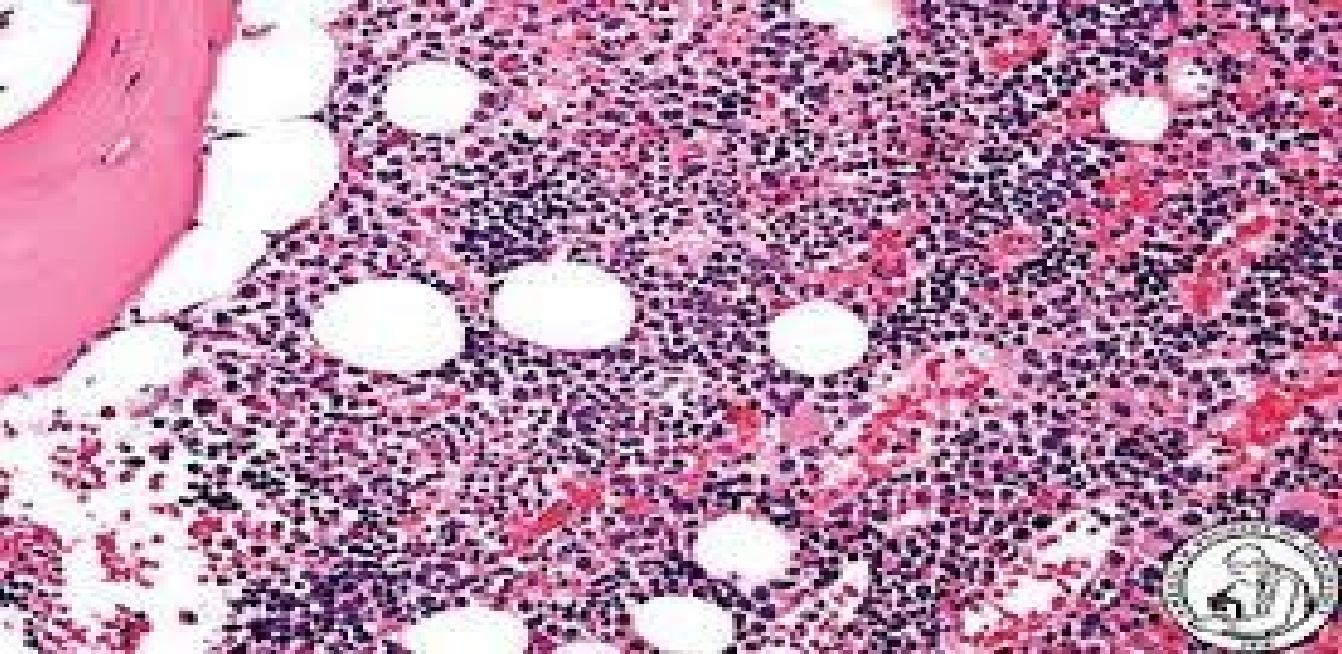
# 2 Types



Re  
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Yello  
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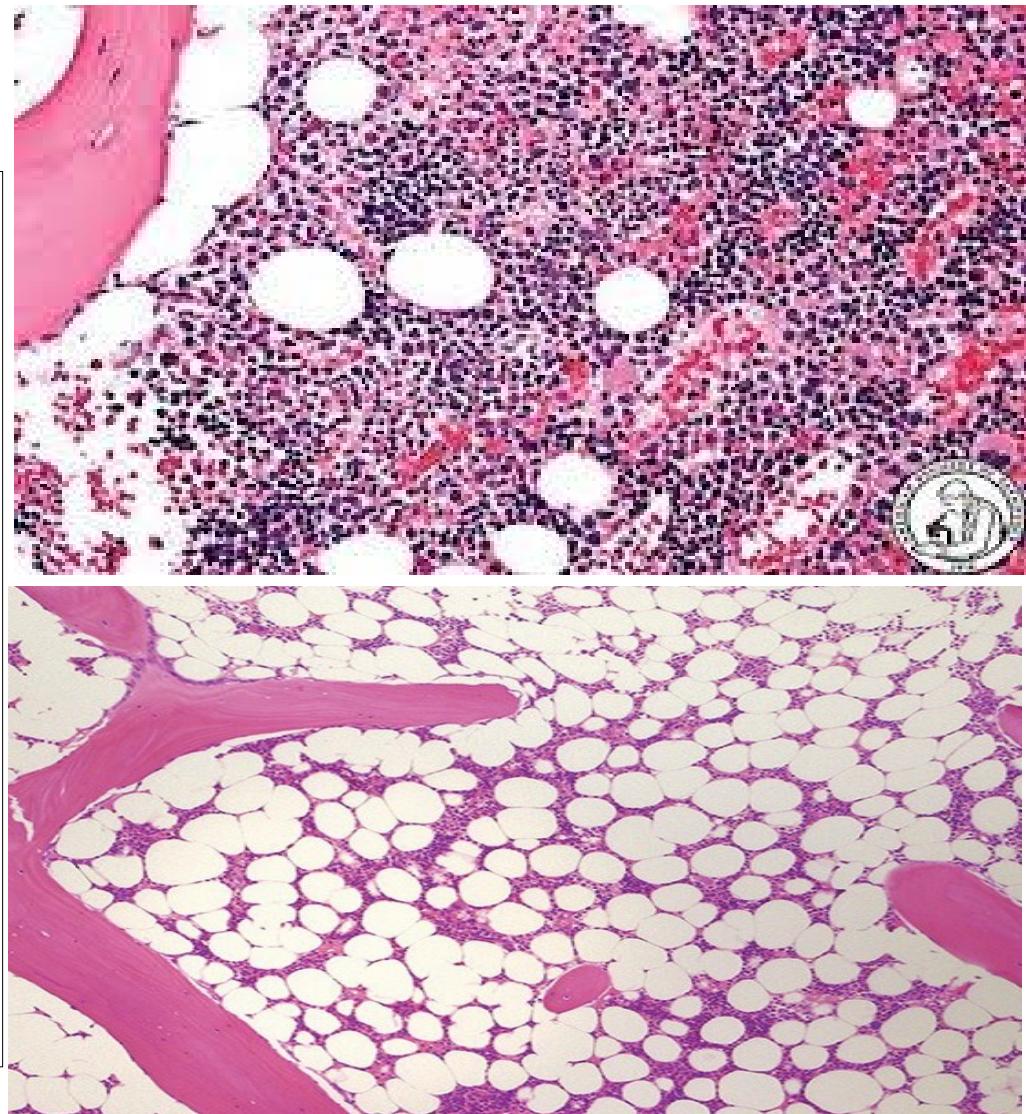
# Bone Marrow:

## 1- Red bone marrow:

- The site of hematopoiesis.
- Red color is due to abundance of blood & hemopoietic cells.

## 2- Yellow bone marrow:

- Inactive for hematopoiesis,
- Yellow color is due to abundance of fat cells





# Bone Marrow

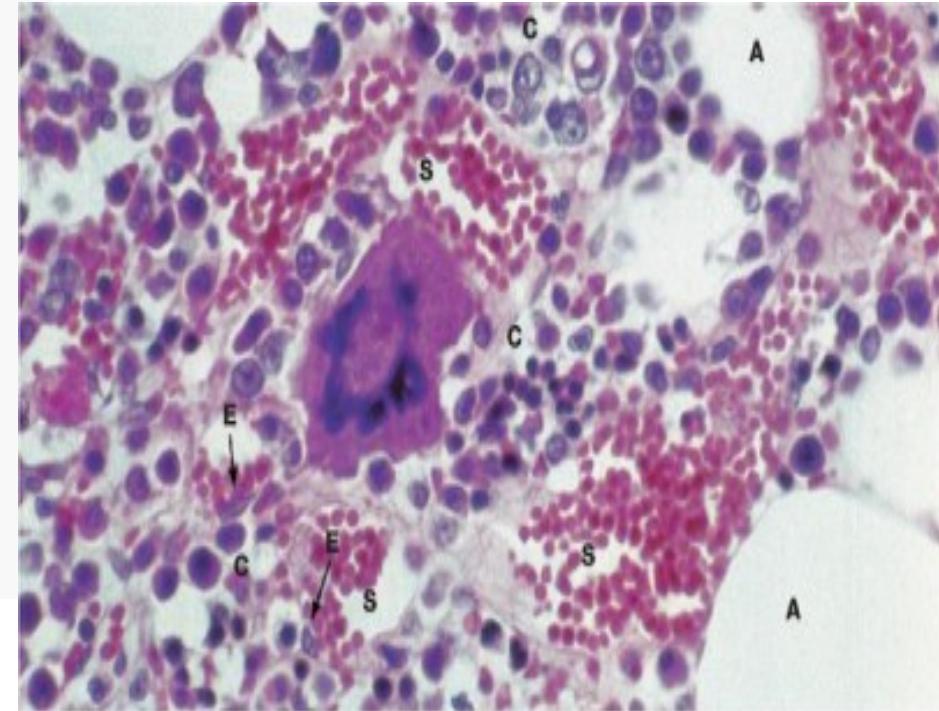
## Sites of red BM:

- In Fetus: all long bones.
- In adult life, red BM is restricted to:
  - Epiphysis of long bones.
  - Some short bones
  - Irregular & flat bones: pelvis, ribs, sternum, bodies of vertebrae, bones of skull vault.

**During growth, red BM is progressively replaced by yellow BM in most of long bones.**

**N.B.:**

In times of increased need for erythrocytes (as in hemolytic anemia), yellow BM can change to red BM



## 2 Ratios

### 1. Haematopoietic-to-fat ratio = “BM cellularity” —

- The ratio between hemopoietic cells to fat cells.
- It changes with age (decrease with age):
  - Newborn to 3 months 80-100%
  - 20-40 years 60-70%
  - 40-70 years 40-50%
- The normal level (adult) is evaluated by the following formula: (100 - the age ±10%).

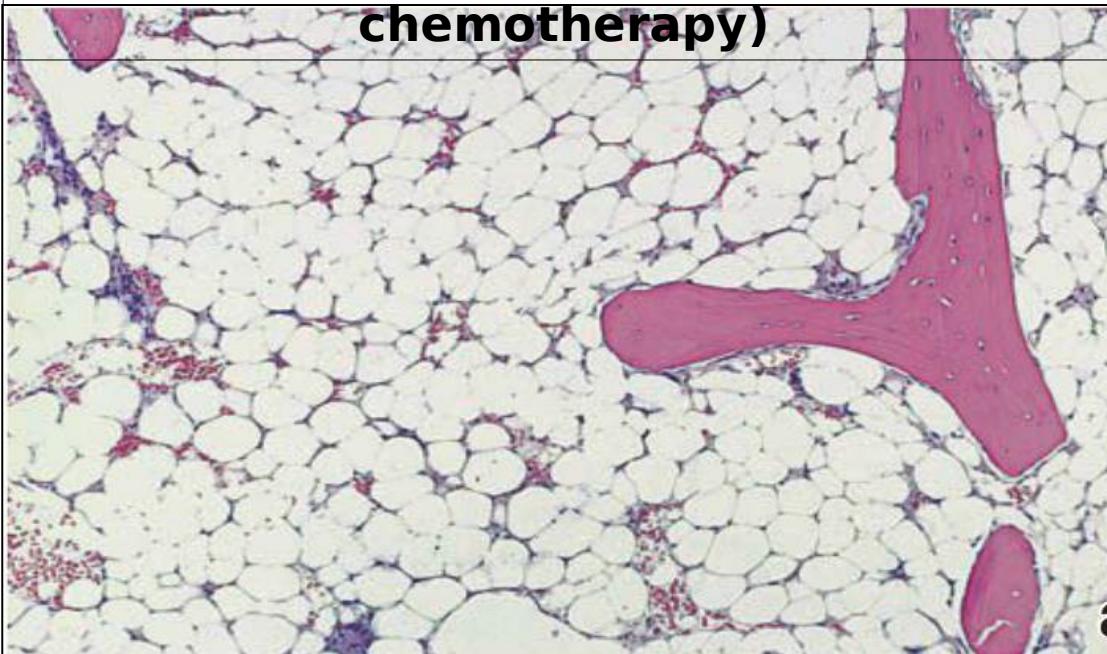


# Bone Marrow

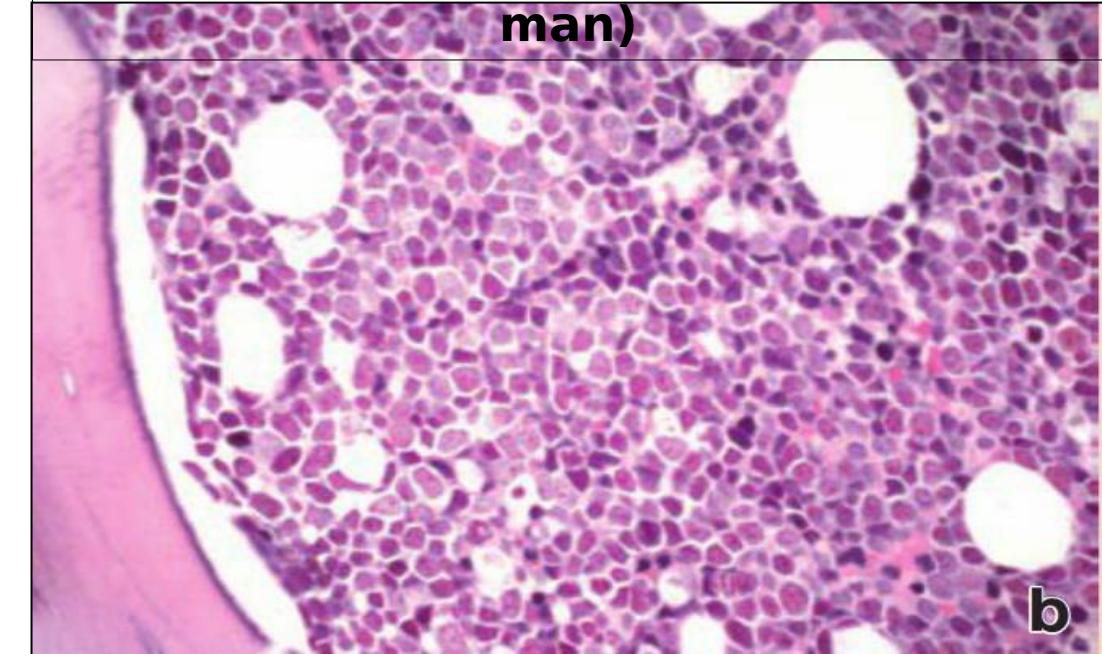
## Clinical correlation: “BM cellularity”

- Hypocellularity: aplastic anemia, chemotherapy
- Hypercellularity: polycythemia , leukemia “proliferation”

**Hypocellular BM (Aplastic anemia , chemotherapy)**



**Hypercellular BM (Tumor in 50 yr old man)**



## 2 Ratios

### 2. Myeloid-to-Erythroid ratio

- The ratio between myeloid to erythroid precursors.
- Normally = 3:1

### Clinical correlation:

- Increased ratio: Chronic myeloid leukemia
- Decreased ratio: erythroid hyperplasia

# Quiz

A 35-year-old woman undergoes routine blood screening as part of a pre-employment physical. The screening demonstrates a mild anemia characterized by small cells with relative pallor compared to normal erythrocytes. Deficiency of which of the following would be most likely to have caused this patient's anemia?

- a) Iron
- b) Folate
- c) Vitamin-B12
- d) Vitamin-C

# **Compare between yellow bone marrow and red bone marrow**

	<b>Yellow marrow</b>	<b>bone</b>	<b>Red marrow</b>	<b>bone</b>
Site				
Structure				
Function				

- **Mention the cells in the erythropoietic series that can undergo self renewal**
- **Describe the reticulocytes and assess the value of counting them.**

# SUGGESTED TEXTBOOKS



- 1. Junqueira's Basic Histology; Text and Atlas. 14<sup>th</sup> edition 2018.**
- 2. Histology A Text and Atlas: Michael H. Ross and Wojciech Pawlina, 7<sup>th</sup> edition, 2016.**

Thank  
you

